Monitoring and Adaptive Management Sections for Tidal Marsh Restoration Conservation Measures SAIC Working Draft (March 4, 2009)

HRCM4: Restore a mosaic of __ to __ acres of freshwater tidal marsh, shallow subtidal aquatic, and transitional grassland habitat within the Yolo Bypass/Cache Slough Complex Restoration Opportunity Area.

Performance Monitoring Metrics #1-2: Vegetative structure (percent absolute cover) and composition (percent relative cover of native emergent vegetation)

Rationale: Vegetative cover and composition are primary components of tidal marsh that support food production and habitat for covered species.

Target: Absolute vegetation cover within the restored tidal marsh of at least __ percent and __ percent comprised of at least __ percent and __ percent native emergent vegetation within 5 and 10 years following restoration, respectively.

Monitoring approach: Percent absolute vegetative cover will be determined in years 1, 2, 5, 8, and 10 following restoration through use of aerial photography or other appropriate method that would yield comparable results. Percent relative cover of native emergent vegetation will be determined in years 1, 2, 5, 8, and 10 following restoration using a statistically valid survey sampling design and methods to be determined by the Implementing Entity.

Adaptive management triggers and responses: If monitoring surveys indicate that vegetative cover and composition is not trending towards achieving targets, the Implementing Entity will conduct investigations to determine the likely cause(s). Based on investigation results, the Implementing Entity will implement appropriate actions to improve vegetative cover and composition. Potential actions could include controlling non-native emergent vegetation, planting native emergent vegetation, and modifying designs of future tidal marsh restoration projects to improve their likelihood for achieving targets. If investigation results indicate that targets are inappropriate relative to site capabilities, targets may be revised through the adaptive management process.

Performance Monitoring Metric #3: Non-native predatory fish abundance (ratio of non-native predatory fish to native fish).

Rationale: Restoration of tidal marsh would include creation of shallow subtidal habitats adjacent to restored marsh plains. This monitoring is necessary to determine if these subtidal areas develop as habitat for non-native predatory fish such that their abundance precludes effective use of the restored tidal marsh and adjacent habitats by covered fish species.

Target: The abundance of juvenile and adult non-native predatory fish in restored marsh channels and shallow subtidal habitats adjacent to restored marsh should not exceed a ratio of __:__ to with native fish species.

Monitoring approach: Conduct monthly fish sampling surveys within Delta channels adjacent to tidal marsh restoration sites for a least one year before restoration is implemented using survey methods consistent with the current Suisun Marsh fishery survey program and additional survey methods as needed (e.g., beach seine, otter trawl, tow net, ichthyoplankton net) to establish baseline conditions. Following restoration, initiate comparable surveys within marsh channels and in adjacent Delta waterways and continue surveys until a relationship is established between the abundance of non-native predatory fish and covered fish species and the extent and function of restored tidal marsh is established. Subsequently, surveys would be conducted at least every five years to document any changes that may occur in use of restored marshes and adjacent Delta waterways over the term of the BDCP.

Adaptive management triggers and responses: If the abundance of non-native predatory fish exceeds target levels, the Implementing Entity will undertake investigations to determine causes for their abundance or determine if the targets were established incorrectly given the uncertainties surrounding the internal and external factors that govern the distribution and use of habitats by non-native predatory fish. Potential actions to reduce the abundance of non-native predatory fish could include actions to remove them from restored habitats or, if supported by investigations, adjusting designs of restored tidal marshes to create habitat conditions that disfavor their use by non-native predatory fish (e.g., removal of non-native submerged aquatic vegetation).

Performance Monitoring Metric #4: Non-native submerged and floating aquatic vegetation.

Justification: Restoration of tidal marsh would include creation of shallow subtidal habitats adjacent to restored marsh plains. This monitoring is necessary to determine if non-native submerged and floating aquatic vegetation establish in densities such that they substantially increase the risk for predation of covered fish species and/or substantially decrease turbidity as a result of filtering particles from the water column.

Target: Non-native submerged and floating aquatic vegetation should occupy less than __ percent of the surface area of shallow subtidal habitats adjacent to restored marshes.

Monitoring approach: For the first __ years following completion of tidal marsh restoration projects, annually conduct aerial and/or field surveys (e.g., sonar for *Egeria*) in October to map the extent of non-native submerged and floating aquatic vegetation in shallow subtidal habitats adjacent to restored tidal marsh

habitats. Subsequently, if supported by survey results and effects of any treatments implemented to reduce the extent of non-native submerged and floating aquatic vegetation, future surveys would be conducted at least every five years to document any changes in the extent of non-native submerged and floating aquatic vegetation adjacent to restored tidal marshes over the term of the BDCP.

Adaptive management triggers and responses: If initial annual surveys indicate that the extent of non-native submerged and floating aquatic vegetation is trending towards exceeding target levels, the Implementing Entity will implement actions to control non-native submerged and floating aquatic vegetation. The Implementing Entity would also undertake investigations to determine causes for their abundance. If supported by results of these investigations, designs of subsequent restored tidal marshes would be adjusted as appropriate to create conditions that would further discourage the establishment of non-native submerged and floating aquatic vegetation.

Effectiveness Monitoring Metrics #1-3: Total organic carbon (mg/L), phytoplankton (mg/L chlorophyll a), and zooplankton (number/1,000 m^3)

Hypothesis: Restoration of tidal marsh will increase the production and transport of organic carbon into adjacent Delta waterways. Total organic carbon, phytoplankton, and zooplankton production within and export from restored tidal marshes into Delta waterways are primary constituents of food production for covered fish species (Sommer et al 2001a, Schemel et al. 2004). Measurements of these constituents, therefore, are indicators of the contribution of this conservation measure towards improving food production potential within the Delta.

Target: Increase mean annual total organic carbon concentrations entering Delta waterways adjacent to restored tidal marsh relative to concentrations in the channels before marsh is restored by at least __ percent and chlorophyll a concentrations and zooplankton densities within Delta waterways adjacent to restored tidal marsh by at least __ and __ percent, respectively within __ years of restoration

Monitoring approach: Take weekly grab samples and measurements for total organic carbon, chlorophyll a, and zooplankton in Delta waterways adjacent to tidal marsh restoration sites for a least one year before marsh is restored to establish baseline conditions in adjacent waterways. Following restoration, annually take weekly grab samples and measurements for total organic carbon within restored marshes and for chlorophyll a and zooplankton in Delta waterways adjacent to restored marshes. Assess measurements of total organic carbon, chlorophyll a, and zooplankton and performance monitoring results to establish relationships between restored tidal marsh extent and structure as restored marsh develops and production and export of total organic carbon, chlorophyll a, and zooplankton. Once these relationships have been established,

annual monitoring of would be discontinued and a more limited monitoring effort to be determined by the Implementing Entity would be conducted every fifth year that the Fremont Weir is operated to document any changes in production of these constituents over the term of the BDCP.

Adaptive management triggers and responses: If production and export of total organic carbon, chlorophyll a, and zooplankton do not achieve the targets, the Implementing Entity will undertake investigations to determine causes for insufficient production and export of these constituents or determine if the targets were established incorrectly given the uncertainties surrounding the internal and external factors that govern the capacity of restored tidal marshes to produce these constituents. Potential actions, if appropriate, that could be undertaken could include modifying tidal marsh restoration designs to improve vegetative structure and composition and tidal exchange to improve production and export of these constituents.

Effectiveness Monitoring Metric #4: Abundance of covered fish species (number of covered fish species/10,000 m^3)

Hypothesis: Restoration of tidal marsh will improve habitat conditions for covered fish species, increasing their abundance in and adjacent to restored tidal marshes. Change in abundance of covered fish using restored tidal marsh channels and adjacent Delta waterways will provide the Implementing Entity with information necessary to determine the effectiveness of restoring tidal marsh as a tool to improve habitat conditions (e.g., local food availability, hydrodynamics, water temperature) for covered fish species.

Target: Increase the abundance of each covered fish species inhabiting restored tidal marsh channels and adjacent Delta waterways by __% relative to their abundance in Delta waterways adjacent to restoration sites before restoration is implemented.

Monitoring approach: Conduct monthly fish sampling surveys within Delta channels adjacent to tidal marsh restoration sites for a least one year before restoration is implemented using survey methods consistent with the current Suisun Marsh fishery survey program and additional survey methods as needed (e.g., beach seine, otter trawl, tow net, ichthyoplankton net) to establish baseline conditions. Following restoration, initiate comparable surveys within marsh channels and in adjacent Delta waterways and continue surveys until a relationship is established between the abundance of each covered fish species and the extent and function of restored tidal marsh is established. Subsequently, surveys would be conducted at least every five years to document any changes that may occur in use of restored marshes and adjacent Delta waterways over the term of the BDCP. Monitoring results would be used to assess the effectiveness of restoring tidal marsh in achieving covered fish species biological goals and objectives relative to other conservation measures.

Adaptive management triggers and responses: If the abundance of covered fish species is not increased to target levels, the Implementing Entity will undertake investigations to determine causes for low abundance or determine if the targets were established incorrectly given the uncertainties surrounding the internal and external factors that govern the distribution and use of habitats by covered fish species. If low use of restored tidal marsh is attributable to insufficient food production or elevated predatory fish abundance, potential implementation of actions to improve these conditions would be same as described for Effectiveness Monitoring Metrics #1-3 and Performance Monitoring Metrics #3-4, respectively.

HRCM5: Restore a mosaic of __ to __ acres of freshwater tidal marsh, shallow subtidal aquatic, and transitional habitat within the Cosumnes/Mokelumne ROA.

Performance monitoring and effectiveness monitoring metrics, justifications, hypotheses, targets, monitoring approach, and adaptive management triggers and responses are the same as described for conservation measure HRCM4.

HRCM6: Restore a mosaic of __ to __ acres of freshwater tidal marsh and shallow subtidal aquatic habitat within the West Delta Restoration Opportunity Area.

Performance monitoring and effectiveness monitoring metrics, justifications, hypotheses, targets, monitoring approach, and adaptive management triggers and responses are the same as described for conservation measure HRCM4.

HRCM9: Restore a mosaic of __ to __ acres of freshwater tidal marsh, shallow subtidal aquatic and transitional grassland habitat within the South Delta Restoration Opportunity Area.

Performance monitoring and effectiveness monitoring metrics, justifications, hypotheses, targets, monitoring approach, and adaptive management triggers and responses are the same as described for conservation measure HRCM4.

HRCM10: Restore a mosaic of __ to __ acres of freshwater tidal marsh, shallow subtidal aquatic, and transitional grassland habitat within the East Delta Restoration Opportunity Area.

Performance monitoring and effectiveness monitoring metrics, justifications, hypotheses, targets, monitoring approach, and adaptive management triggers and responses are the same as described for conservation measure HRCM4.

HRCM11: Restore a mosaic of __ to __ acres of brackish tidal marsh, shallow subtidal aquatic, and transitional grassland habitat within the Suisun Marsh Restoration Opportunity Area.

Performance Monitoring Metrics #1-2: Vegetative structure (percent absolute cover) and composition (percent relative cover of native emergent vegetation)

The justification, monitoring approach, and adaptive management triggers and responses for these metrics are the same as described for conservation measure HRCM4.

Target: Absolute vegetation cover within the restored brackish tidal marsh of at least __ percent and __ percent comprised of at least __ percent and __ percent native emergent vegetation within 5 and 10 years following restoration, respectively.

Performance Monitoring Metric #3: Non-native predatory fish abundance (ratio of non-native predatory fish to native fish).

The justification, monitoring approach, and adaptive management triggers and responses for these metrics are the same as described for conservation measure HRCM4 , except that monitoring would take place within shallow subtidal habitats of Suisun Bay and Suisun Marsh sloughs adjacent to restored habitats.

Target: The abundance of juvenile and adult non-native predatory fish in restored marsh channels and shallow subtidal habitats adjacent to restored marsh should not exceed a ratio of __:__ to with native fish species.

Effectiveness Monitoring Metrics #1-3: Total organic carbon (mg/L), phytoplankton (mg/L Cholrophyll A), and zooplankton (number/1,000m^3)

The hypotheses, monitoring approach, and adaptive management triggers and responses for these metrics are the same as described for conservation measure HRCM4 , except that monitoring would take place within shallow subtidal habitats of Suisun Bay and Suisun Marsh sloughs adjacent to restored habitats.

Target: Increase mean annual total organic carbon concentrations entering Suisun Marsh channels and Suisun Bay adjacent to restored brackish tidal marsh relative to concentrations in the channels and Bay before marsh is restored by at least __ percent and Chlorphyll A concentrations and zooplankton densities within Suisun Marsh channels and Suisun Bay adjacent to restored tidal marsh by at least __ and __ percent, respectively within __ years of restoration.

Effectiveness Monitoring Metric #4: Abundance of covered fish species (number of covered fish species/10,000^3)

The hypotheses, monitoring approach, and adaptive management triggers and responses for this metric is the same as described for conservation measure HRCM4 , except that monitoring would take place within shallow subtidal habitats of Suisun Bay and Suisun Marsh sloughs adjacent to restored habitats.

Target: Increase the abundance of each covered fish species inhabiting restored brackish tidal marsh channels and adjacent Suisun Marsh/Bay waterways by __% relative to their abundance in Suisun Marsh/Bay waterways adjacent to restoration sites before restoration is implemented.

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Additional Pers. comms.

D. Fullerton (Biologist, MWD) email to R. Wilder, 11/17/2008 about abundance correlations with ammonia.

A. Munevar (Hydrologist, CH2M Hill) presentation to HOTT Team on 6/18/2008 on the effects of South Delta tidal marsh restoration on hydrodynamics.